Tenth Quarterly Status and Technical Progress Report

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INVESTIGATION OF ANTARCTIC CRUST AND UPPER MANTLE USING MAGSAT AND OTHER GEOPHYSICAL DATA

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Figures 1-4 show the scalar (ΔB), radial vector (ΔX), tangential vector (ΔY), and vertical vector (ΔZ) anomalies. ΔX is positive to the north, ΔY to the east and ΔZ upward. The coordinate system is left-handed. Passes chosen as data used to make up these figures satisfied the following criteria:

1. $Kp < 1^-$ for 6 hours,
2. $|\Delta Z| < 25$ nT for all points on the pass,
3. $|\Delta B| < 20$ nT for all points on the pass,
4. $-\Delta Z$ and ΔB are highly correlated.

Criteria 2-4 were to be satisfied after a quadratic polynomial was least-squares fitted to the sequence B-BMOD, where B is the observed field and BMOD is the spherical harmonic field model value. The flight tracks of the 88 passes that satisfied these criteria can be seen in Figure 5. Characteristics of these passes are listed in Table I, where our pass n contains data from NASA's south-going pass n and north-going pass n + 1.

An interesting effect can be observed in Figure 6. Though the geometry of field-aligned currents implies that most of their effect will lie in the horizontal plane and thus not affect the scalar anomaly greatly, the ΔZ anomaly clearly shows signs of being affected by field-aligned currents. Notably, ΔZ shows anomalies too high in amplitude and spatial frequency to be geologically caused. (Also note that the ΔZ graph is sign-reversed relative to Figure 4 so that ΔB and ΔZ are expected to be anti-correlated.) However, these high-frequency and amplitude anomalies do not find their way into the

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scalar anomalies. Interestingly lower-frequency field-aligned current anomalies in ΔZ do find their way into ΔB as can be seen in Figure 7. This leads us to believe that some sort of induction effect is taking place that generates a horizontal anomaly which acts to counteract the anomalies in ΔZ. We remain uncertain about the cause of this phenomenon, however its existence is useful--it effectively filters high-frequency field-aligned current effects. The phenomenon can mislead investigators using a scalar magnetometer alone, for affected passes may show a relatively quiet scalar anomaly as can be seen in Figure 8.

Filtering polynomials from MAGSAT passes in non-polar regions where passes do not cross is the source of the latitudinal striping apparent in low-latitude MAGSAT anomaly maps, e.g. Langel et al (1982). Removal of the polynomials amounts to removal of most long-wavelength North-South power so that only long-wavelength East-West power remains; thus, the East West striping. In polar regions, flight paths cross so that this problem is not generated. Therefore, Antarctica is the perfect proving ground for testing alternate data reduction procedures to the standard procedure employing polynomial fitting. Cain et al (1982) have tested a whole-earth two-dimensional spherical harmonic method with that they feel to be surprisingly good results. We have tested another method on a continental scale with somewhat ambighuous, though heartening, results.

Instead of subtracting a polynomial from each pass we have merely taken the unreduced data (observed values minus core-field model for each pass) and averaged them in 3° square bins. The resulting map was then high pass filtered using a two-dimensional finite Fourier transform filter so that spectral peaks between 4200 km and 5280 km were diminished by 1/3, peaks corresponding to wavelengths greater than or equal to 5280 km were diminished

by 1/2, and the d.c. component was set equal to zero. The surface extracted in this way is shown in Figure 10. This surface differs from the polynomials used in the standard method in that it is static over the 5 north data window whereas the polynomials in the standard reduction procedure can be viewed as two-dimensional slices of a three-dimensional surface varying during the same 5 months. The map produced can be seen in Figure 9. The question is, how well does the static model correspond to the dynamic model?

The difficulty in comparing the effects of the two models is exacerbated by the fact that the no-data region due to the tilt in the satellite's orbit was filled in by linear-interpolation to perform the Fourier transform. The spectrum will be affected, probably by adding long-wavelength power, since the linear interpolation acts to create a long-wavelength feature. Furthermore, the zero-levels of the two maps are not the same--they are the averages of each map, separately, and since Figure 9 does not possess as much oceanic region as Figure 1 its average will be somewhat higher--approximately .4 nT. Thus, features on Figure 9 are d.c. shifted by about .4 nT below features on Figure 1. Comparing the maps indicates that there is a pretty good qualitative correlation--highs in Figure 1 are matched with highs in Figure 9, and lows with lows. There are two major exceptions, the Antarctic Peninsula high in Figure 1 is matched to a low in Figure 9, though this region is still a high relative to Ellsworth Land and the surrounding oceans. Also, the radial feature found at approximately 75°S and 150°W is not found in Figure 1. In general, however, the qualitative agreement between the two maps is good. The radial striping in Figure 9 is reminiscent of that found in Ritzwoller and Bentley (1982), which was believed largely to result from field-aligned current effects disturbing individual passes.

The quantitative agreement is not so good, however. Amplitudes can be a factor of two greater in Figure 9 than in Figure 1. This is the result of the fact that the static model cannot accomodate daily and seasonal changes taking place in the magnetosphere or long-spatial wavelength changes due to field-aligned currents. The latter is a problem specific to high latitudes.

Keeping the problems specific to polar regions in mind, i.e., anomalies in Figure 9 can be generated by field-aligned currents and the data gap, the correlation between the two maps should be considered heartening to the low-latitude investigator who mourns for North-South magnetic features.

In conclusion, experimentation with modifications of the static field model by low-latitude investigators is believed to be warranted. Two-dimensional filtering should be carried out after the removal of a magnetospheric field model (e.g. the model of Langel et al (1982)). If the magnetospheric field model contains fields generated solely in the magnetosphere, subtraction of this model will not create a striping problem. Perhaps then magnetic anomalies associated with such North-South features as the Mid-Atlantic Ridge, the East Pacific Ridge, and the Andes may appear more clearly.

References

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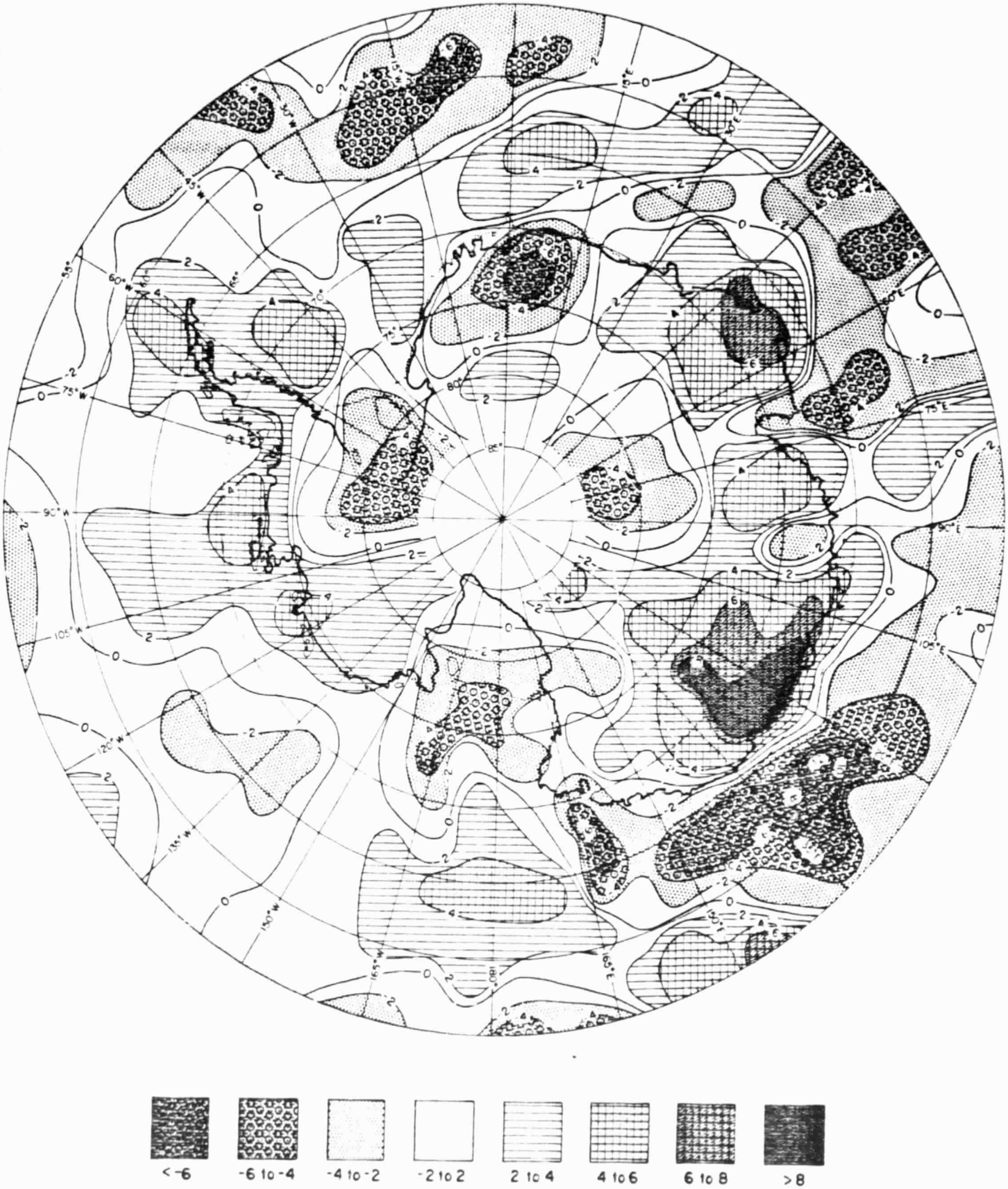
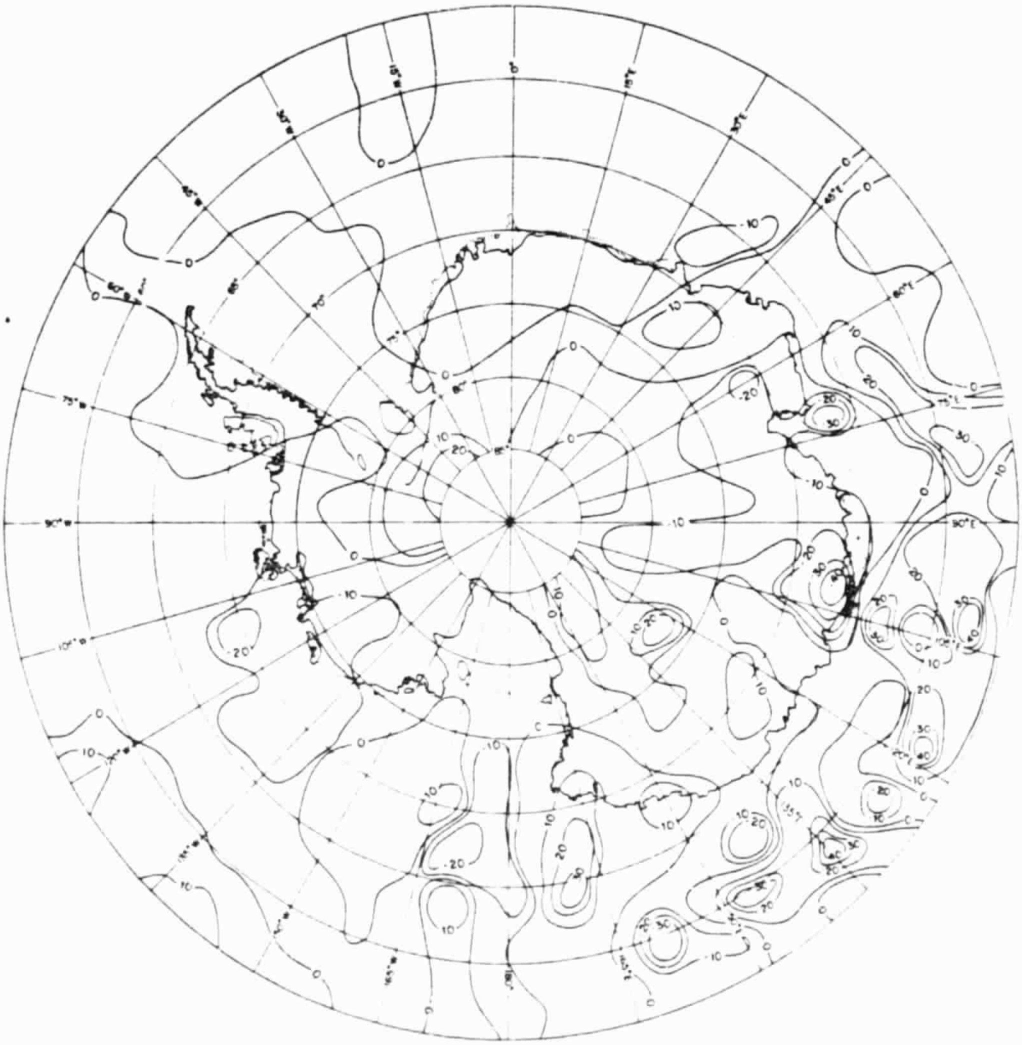


Figure 1



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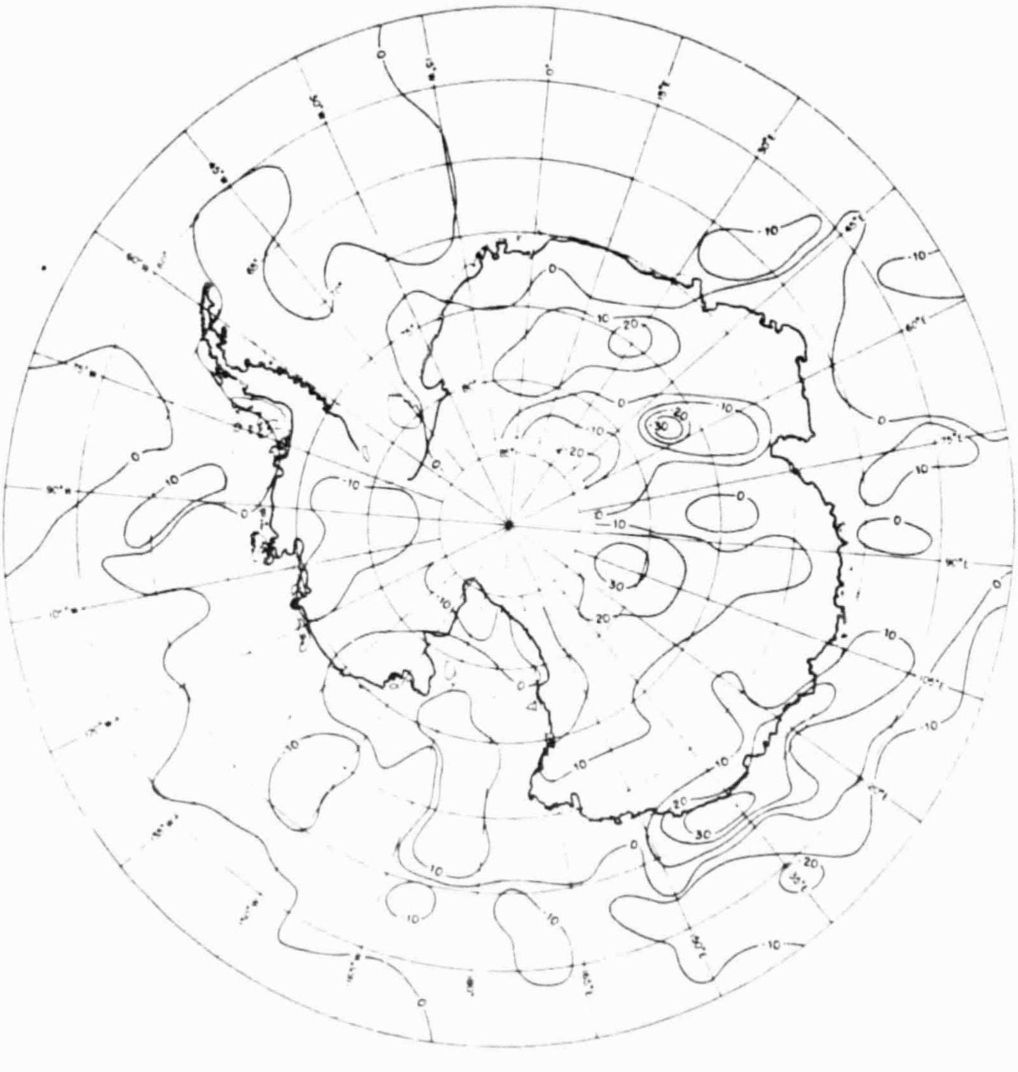

Figure 3

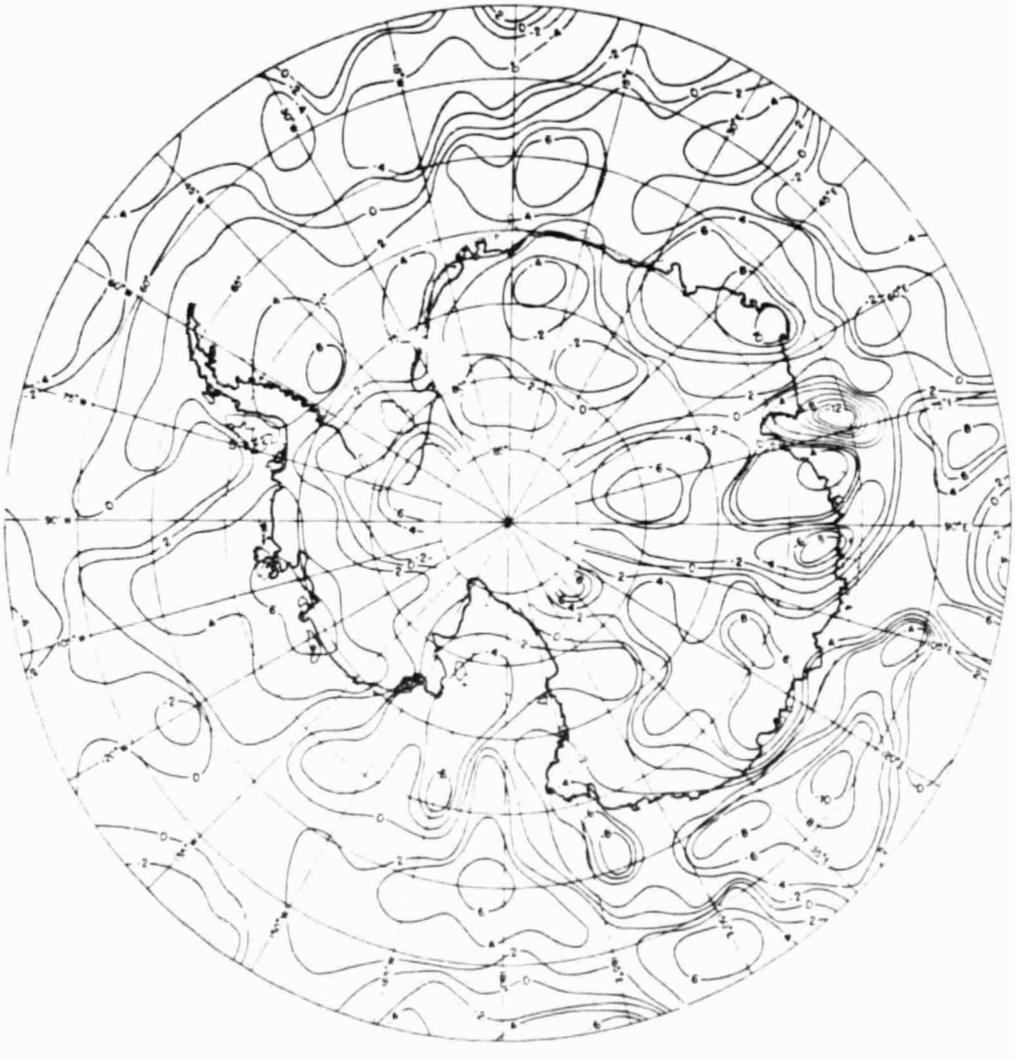

Figure 4

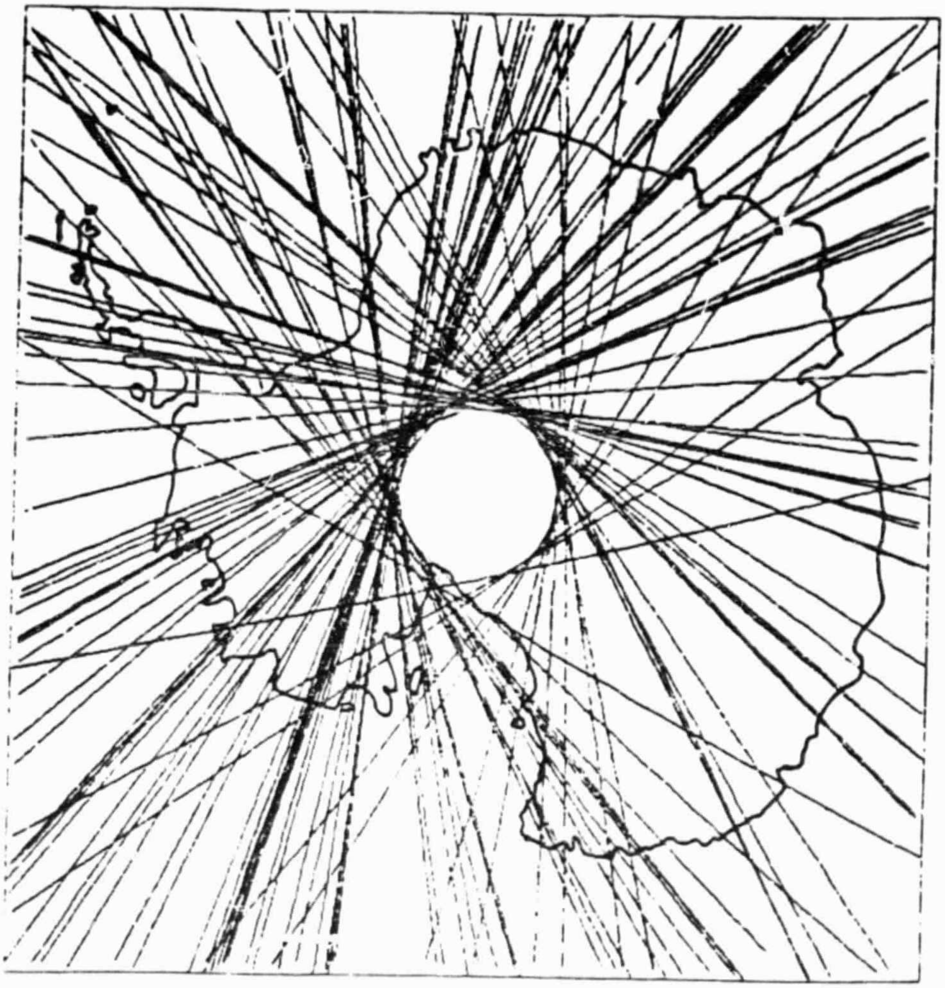

Figure 5

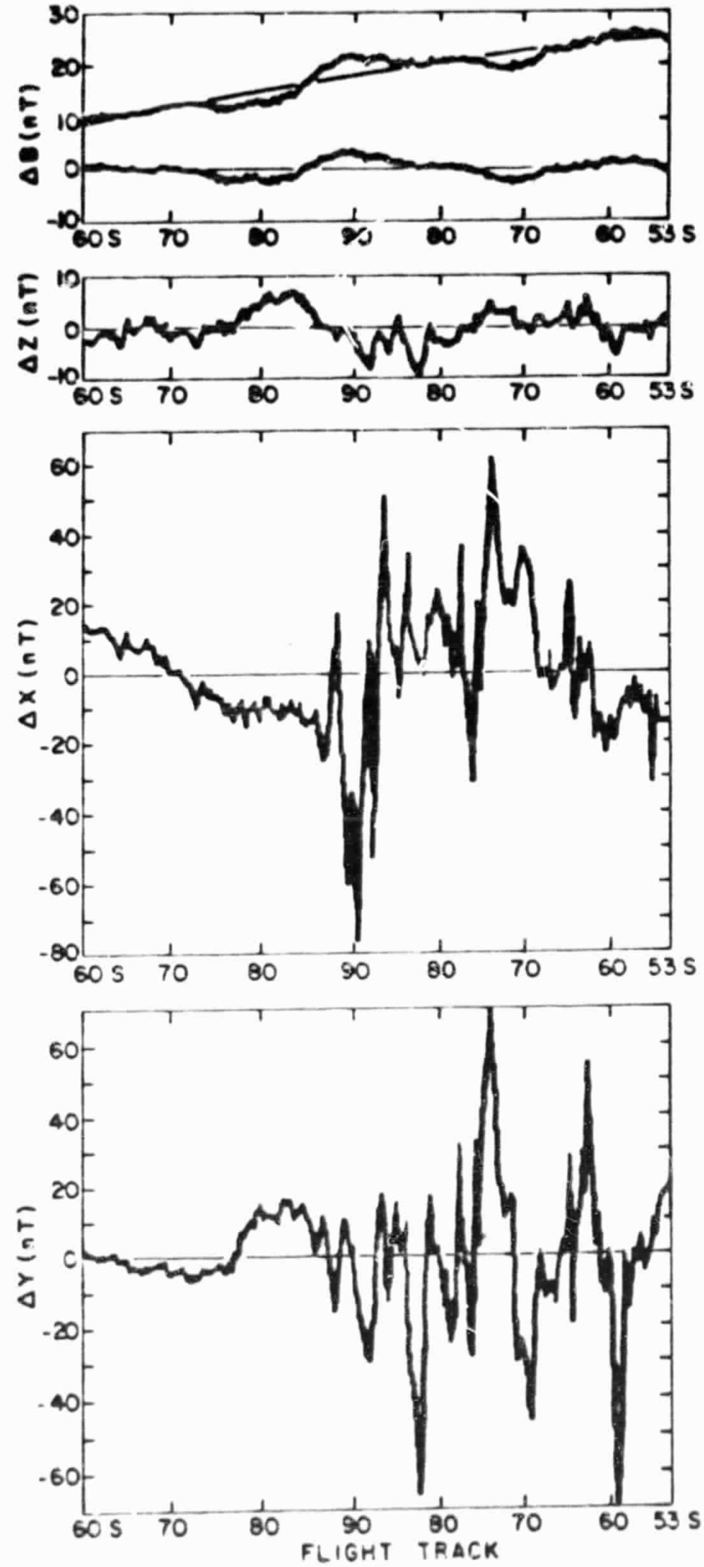

Figure 6

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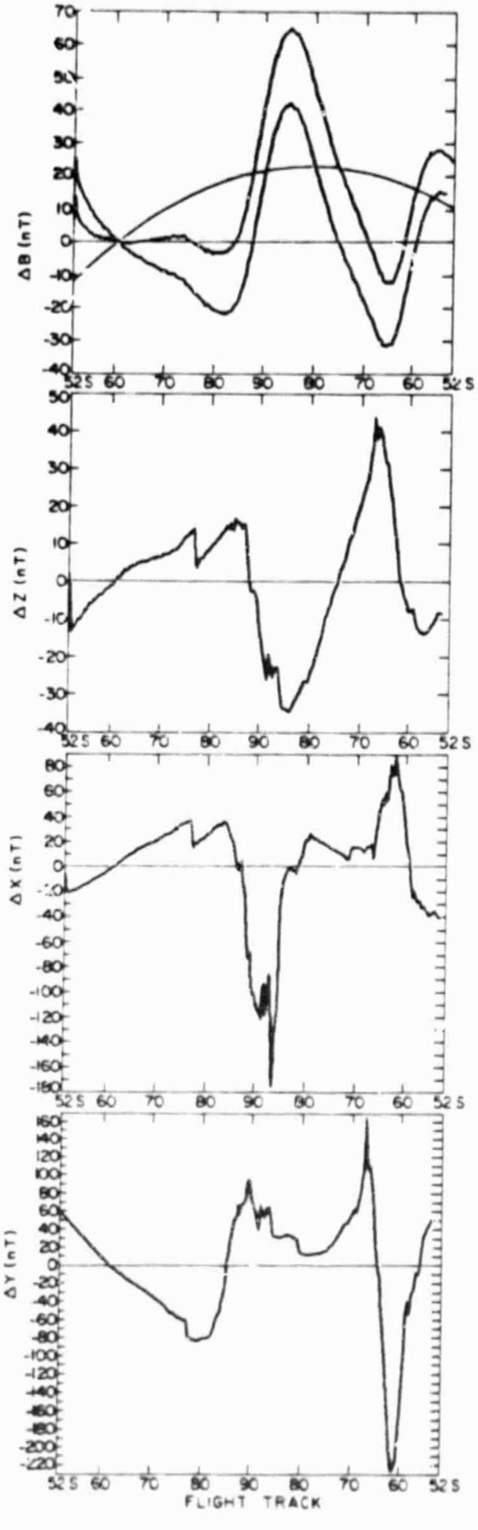

Figure 7

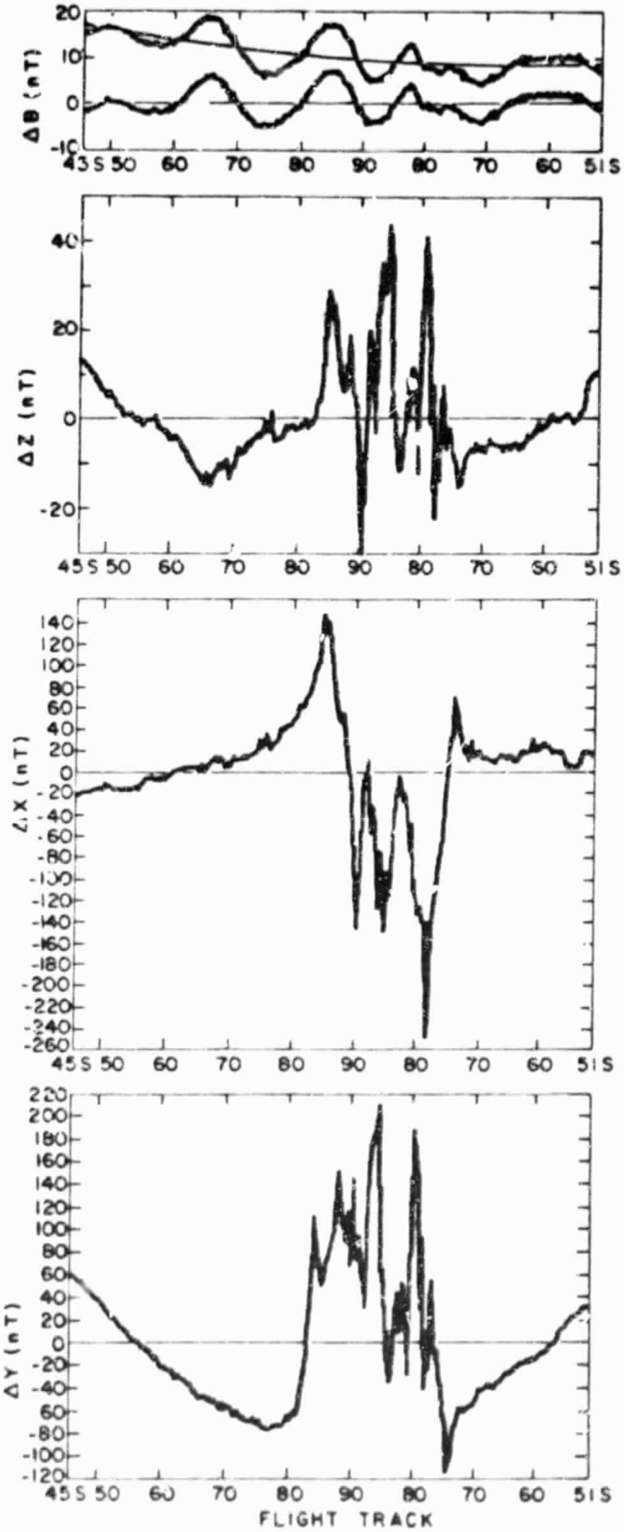

Figure 8

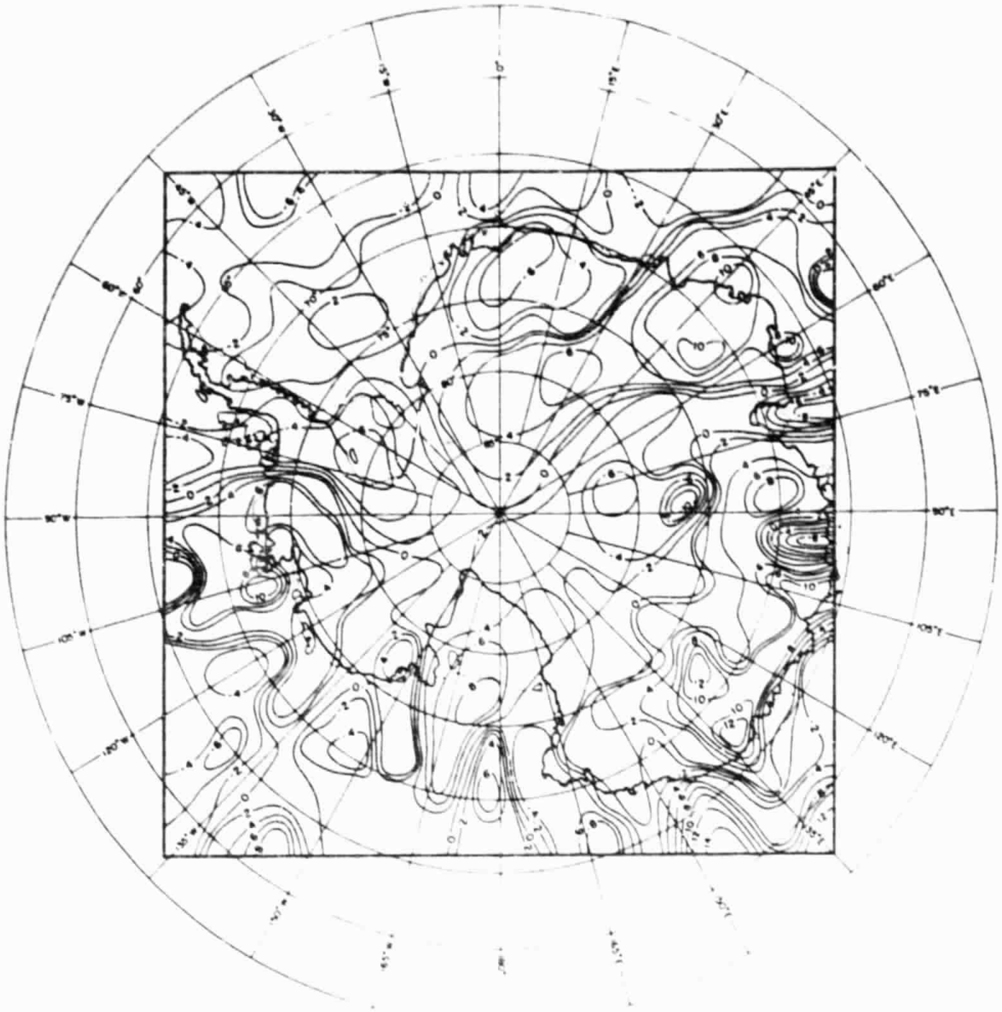

Figure 9

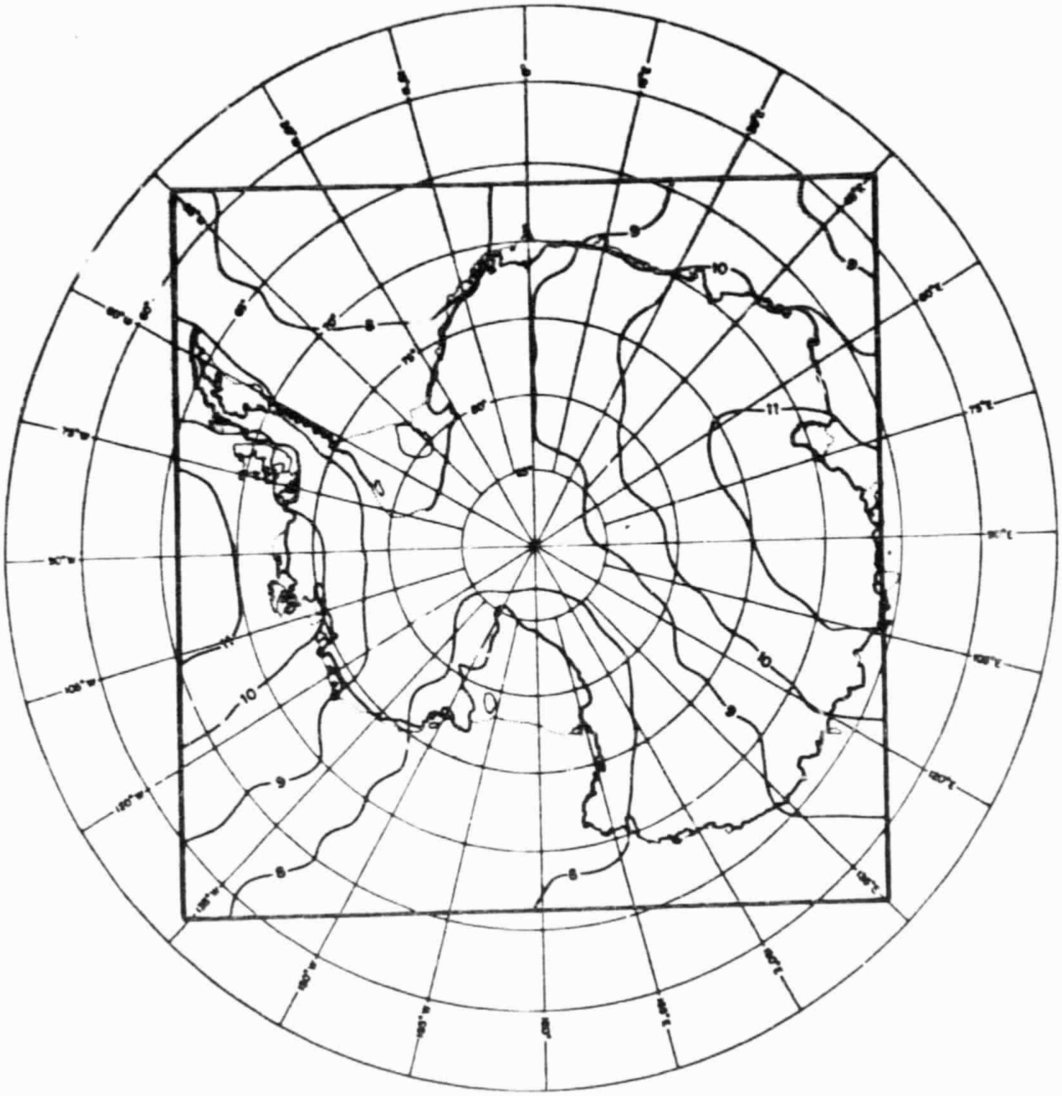

Figure 10